IDAHO NATIONAL ENGINEERING & ENVIRONMENTAL LABORATORY

PLUTONIUM AT THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

This Fact Sheet was prepared to provide you with information about plutonium and to discuss the possibility of human health effects that may result from exposure to it. How dangerous is it? Will it spread to other places? Will I be exposed? This fact sheet will answer some of these questions and help you understand plutonium issues as they relate to planned and future cleanup projects at the Idaho National Engineering and Environmental Laboratory (INEEL). More detailed & quantitative information can be found in a series of Waste Area Group Fact Sheets referenced in the Bibliography, in the Records of Decision for the U.S. Department of Energy's (DOE) Environmental Restoration Program and in multiple Environmental Impact Statements for INEEL activities.

AN HISTORICAL PERSPECTIVE ON PLUTONIUM

The world changed in 1938 when the German scientists Otto Hahn and Fritz Strassmann discovered atomic fission: that uranium atoms could split, releasing huge amounts of energy. Fission could be induced by bombarding uranium with neutrons, the subatomic particles found in the nucleus of all elements.

When the atom split, it released not only energy but more neutrons, the implications of which became obvious to physicists around the world. They knew immediately that the other neutrons released by fission could themselves cause more atoms to split, thereby setting off a chain reaction. At around this same period, Glenn Seaborg and others isolated plutonium, and it was realized that this element was preferred to uranium for purposes of nuclear weapons. Reactor grade nuclear material, under controlled conditions, can be used to provide energy, but in an uncontrolled chain reaction, the reactor core may be damaged. However, the core cannot explode like a nuclear weapon. With the discovery by Hahn and Strassmann, the nuclear age had begun.

WHERE DOES PLUTONIUM COME FROM?

There are two sources of plutonium; human-made and natural production. Human-made plutonium comes from directing a stream of neutrons at uranium in the laboratory. Some of the neutrons will be captured by the uranium and subsequent decay results in plutonium (figure 1). This is then chemically separated from the uranium and used in the manufacture of nuclear weapons.

All the plutonium used in nuclear weapons and in nuclear power plants was made after 1941, when the element was first isolated. In the late eighties, the need for additional nuclear weapons diminished. As a result of this, the reactors and chemical processing plants associated with plutonium production were shut down. No plutonium has been produced for nuclear weapons in the United States since 1988.

The Earth was formed some five billion years ago, and uranium was one of its original elements. Uranium is radioactive, which means that its nucleus spontaneously disintegrates as it emits radiation. The disintegration takes place at a constant rate, and in the time since the Earth was formed, a small amount of plutonium was formed from this uranium. Some tiny quantities of natural plutonium can be found in a deposit of uranium at Oklo, in Gabon, West Africa

PLUTONIUM IN IDAHO AND AT THE INEEL

For fifty years, the State of Idaho has been a center of research into commercial, medical and national defense uses of atomic energy. The world's first reactors were designed and built here, and scientists have conducted fundamental research in nuclear physics at various reactors on the INEEL. Small quantities of plutonium waste were separated during

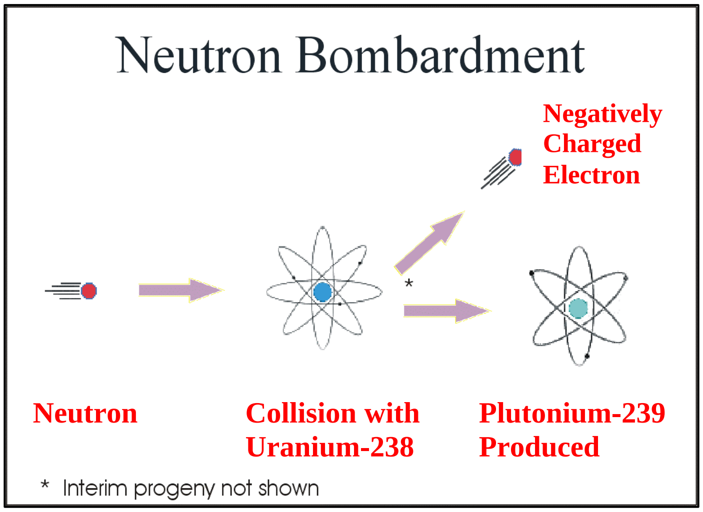

Figure 1. Bombardment of uranium-238 by neutrons produces plutonium-239.

reprocessing of U.S. Navy and other reactor fuels.

In 1992 the decision was made by the U.S Department of Energy (DOE) to discontinue this reprocessing at the Idaho Nuclear Technology and Engineering Center. Plutonium present in the environment at the INEEL is the result of past disposal practices, accidental releases, and global fallout from atmospheric nuclear weapons testing (figure 2).

From 1952 until 1970, wastes containing plutonium were buried in shallow trenches and pits at the Radioactive Waste Management Complex. This was a common method of disposal during those years, and complied with the federal regulations for the nuclear industry at that time. The regulations changed in 1970, and since then plutonium-contaminated waste has been stored above ground at the Radioactive Waste Management Complex.

Much of the plutonium-contaminated waste in Idaho came from the fabrication of plutonium weapons parts at the Rocky Flats Plant near Denver, Colorado and other weapons facilities. Waste that is stored above ground will eventually be moved to the Waste Isolation Pilot Plant near Carlsbad, New Mexico (figure 2). Disposition of the waste that was buried prior to 1970 will be addressed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

ISOTOPES AND HALF-LIFE: WHAT DO THEY MEAN?

A typical element is made up of three fundamental particles: protons and neutrons in the nucleus, and electrons in orbit around the nucleus. Individual atoms of any element may differ in the number of neutrons in the nucleus. Lithium-6 has three protons and three neutrons in its nucleus; lithium-7 has three protons and four neutrons. The different forms are called isotopes.

Isotopes may be either stable or radioactive. Radioactive isotopes decompose spontaneously by emitting an alpha particle, a beta particle or other types of radiation. Eventually these isotopes become stable. The time taken for half of the nuclei in a sample to decay or disintegrate is expressed as its half-life. Carbon-14 is a radioactive isotope, and half of its nuclei decay in about 5730 years. Half of the number left decay in another 5730 years, and so on.

Plutonium-239 is the most common isotope of plutonium in wastes near the Radioactive Waste Management Complex and it has a half-life of 24,000 years. Plutonium-238 is the most common isotope of plutonium in wastes near the Idaho Nuclear Technology and Engineering Center and it has a half-life of 88 years. Other heavy elements have significantly longer half-lives: for example, naturally occurring uranium-238 has a half-life of 4.5 billion years.

In the past, some low-level liquid radioactive waste was disposed of in ways that are no longer acceptable. The liquids were injected into deep wells at the Test Area North until 1972 and at the Idaho Nuclear Technology and Engineering Center until 1986, and although the practice no longer goes on, it was the cause of subsurface contamination at several INEEL sites. There are traces of plutonium in ground water near the INEEL facilities where it was introduced, and there are traces in surface soils. These traces are greater than what would be expected from global fallout from weapons testing and less than amounts that are considered a health hazard.

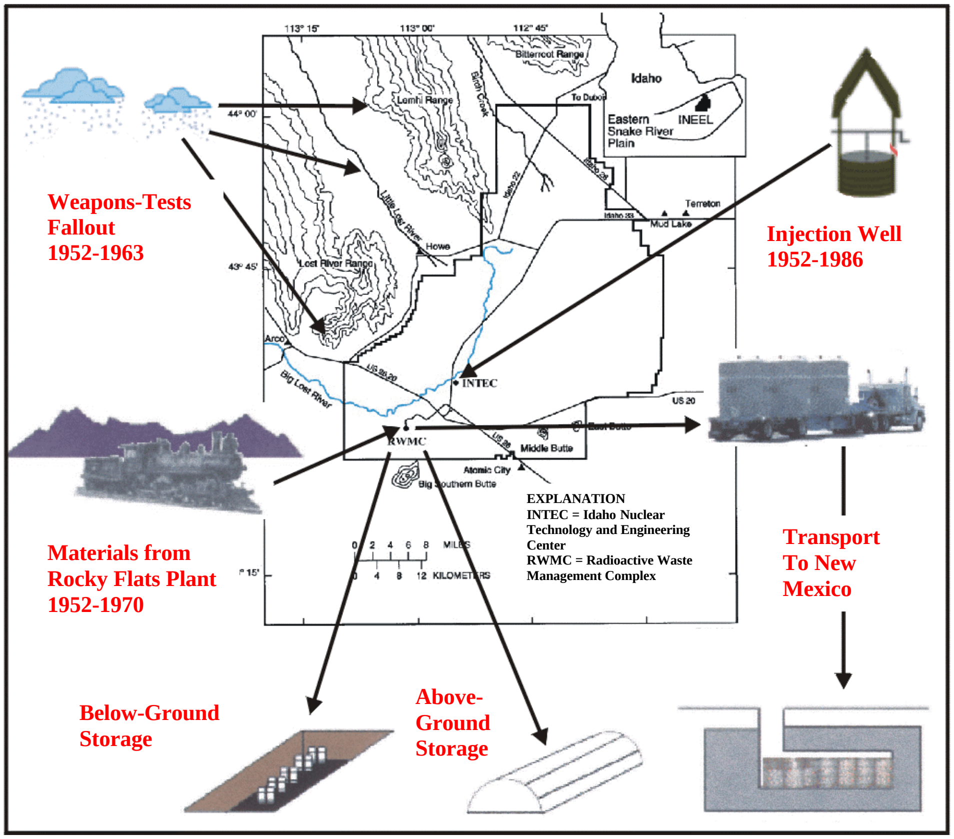

Figure 2. Nuclear waste, transported to INEEL from Rocky Flats, is stored above and below ground. Eventually the waste that is retrieved will be shipped to New Mexico. Nuclear fallout was also deposited in small amounts from atmospheric weapons tests.

Small concentrations of plutonium have been detected in surface soils near the Radioactive Waste Management Complex, and can be attributed to the way disposal was conducted, to flooding in the 1960s, and to natural transport of particles by wind. Similar concentrations of plutonium have been detected in surface soils near the Idaho Nuclear Technology and Engineering Center. This can be attributed to stack emissions and residue from settling ponds, but there have also been some accidental releases and some leaks from pipes. Other facilities at the INEEL have smaller areas of plutonium contaminated soils.

The principal concern for many Idahoans is the contamination of the Snake River Plain aquifer. Figure 3 shows the confirmed occurrences of plutonium in ground water at the INEEL. The distance groundwater has moved since waste-disposal began in 1953 is shown in the explanation on figure 3. Even though ground water has moved an average of 50 kilometers (more than 30 miles) in that time, plutonium has not been detected in the water at distances greater than 1 kilometer (0.6 of a mile) from any of the INEEL facilities. The method used at the INEEL for measuring plutonium in ground water can detect plutonium-238 or plutonium-239 at levels 400 times lower than the amount allowed by drinking water standards.

Plutonium can be dangerous to humans when inhaled, therefore, the quality of the air near

HOW MOBILE IS PLUTONIUM?
Because of its chemical properties, plutonium is one of the least mobile elements. Plutonium in the environment is usually in a chemical form called an oxide. In water, plutonium oxide is less soluble than sand. Plutonium does not dissolve in and move with water unless a strong acid is present or when specific organic solvents combine with it. There has been no detection of these solvents in the aquifer at the INEEL. However, some very small oxide particles can be suspended and carried along with water. Migration of these small particles is limited because they readily adsorb onto the surfaces of the solids with which they come in contact. In soils, plutonium oxide particles adsorb water, become "sticky," and adhere to other particles.

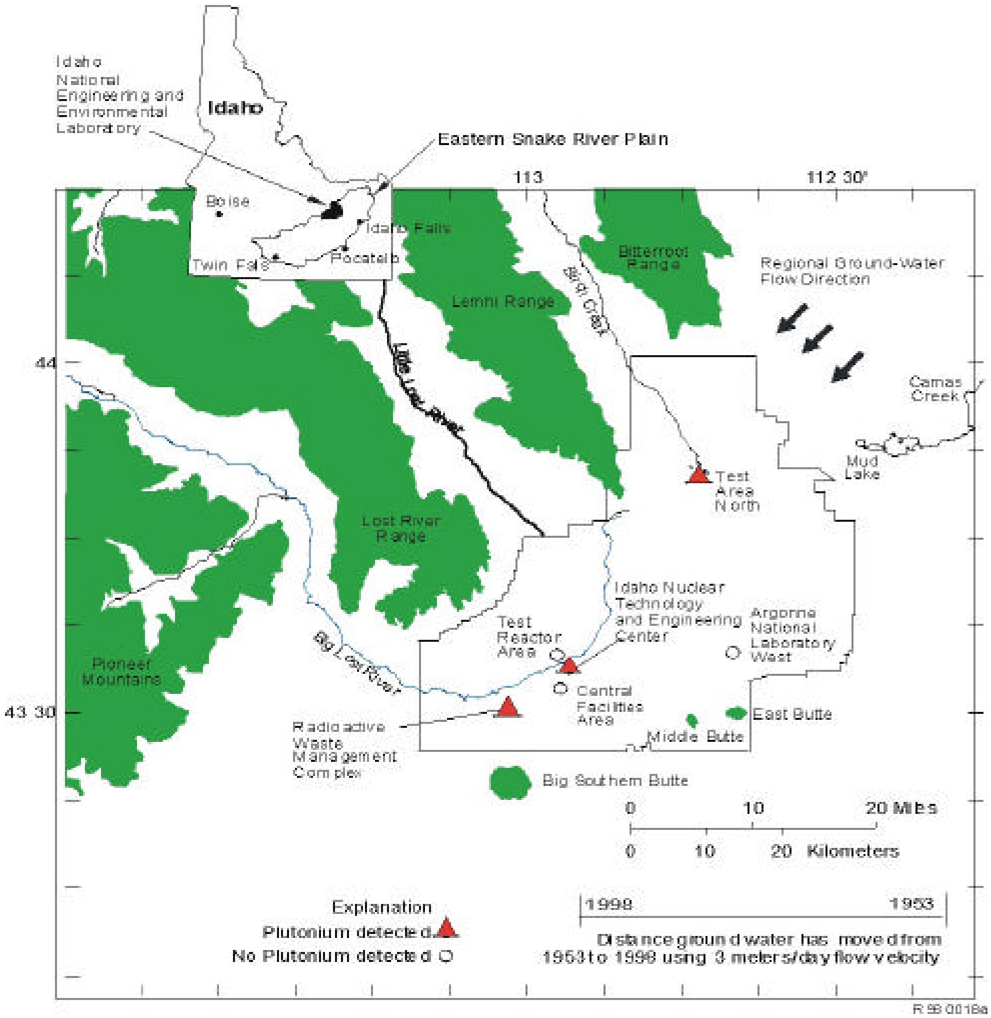

Figure 3. Confirmed occurrences of plutonium in ground water at INEEL facilities.

the INEEL facilities is also of concern. With modern technology, plutonium can be detected on air filters even when it is hundreds of times less concentrated than health standards set by government regulations. We know that plutonium in airborne emissions has dropped in the last decade, and today, even close to INEEL facilities, the amount is so low that it usually cannot be detected.

The standards set by the U.S. Environmental Protection Agency for airborne emissions of radioactive materials in water are very strict for both the general public and for workers at nuclear plants. At the INEEL a long-term and well-established monitoring program ensures that those standards are not and will not be violated. In addition, the State of Idaho Oversight Program and the U.S. Geological Survey provide verification by conducting independent sampling and analysis.

Plutonium is present, at very low concentrations, in the soils and ground water at the INEEL. Its presence at the INEEL is the result of past disposal practices, accidental releases, and global fallout from atmospheric nuclear testing. In some soils its concentration is slightly above global fallout levels. These higher concentrations are restricted to the vicinity of the facilities where it was disposed. In ground water, no detectable concentrations have been found more than 1 kilometer away from the individual facilities where the plutonium was originally disposed. Plutonium concentrations in the aquifer water under the INEEL do not exceed drinking water standards.

WHAT IS MY EXPOSURE TO PLUTONIUM AND HOW DOES IT AFFECT MY HEALTH?

The radiation emitted by plutonium is principally in the form of alpha particles, which are identical to the nucleus of a helium atom, and which consist of two neutrons and two protons. As far as our health is concerned, this is both good news and bad news. It is good news because alpha particles don't travel very far in air and human skin can prevent them from penetrating our bodies. Even a sheet of paper can block alpha radiation.

It may be bad news only if plutonium gets into the lungs or into the bloodstream where it can stay for decades. Once in the body it can expose the surrounding tissues to alpha radiation, damaging nearby cells and increasing the likelihood of developing cancer. The most likely way that anyone can be exposed to plutonium is by breathing it in. Depending upon the size of the particles and upon the chemical form of the plutonium, some may be absorbed into the blood, and some may stay in the lungs. The absorbed material may move to other parts of the body: the bones, liver or other organs. Plutonium that stays in the lungs can be coughed up and swallowed, which reduces its danger because it is not easily absorbed by the digestive system and so passes out as feces.

Breathable plutonium can represent a potential hazard to human health. Therefore, strict standards for airborne emissions are set by the U.S. Environmental Protection Agency. The standards are expressed as the dose of radiation that an adult would receive in one year of exposure to the emissions. (The dose is called a "rem"; and for small quantities, a "millirem", one-thousandth of a rem). For releases to the public from DOE facilities, the dose limit is one hundredth of a rem from all radioactive sources including plutonium. The average citizen of the State of Idaho receives thirty-five times that amount from natural background sources of radiation that have nothing to do with plutonium or the INEEL (figure 4).

The amount of airborne plutonium in Idaho and the world has decreased dramatically since the days of atmospheric testing of nuclear weapons. In 1958, an adult in Idaho is estimated to have received a dose of four-tenths of a millirem from plutonium. In 1988 that dose was calculated to be one hundred thousand times smaller, and by 1997 the dose was smaller still, one ten-millionth of the U.S. Environmental Protection Agency standard for DOE emissions.

Simply stated, the exposure to natural sources of radiation in Idaho is approximately 350 millirems per year including radiation from the sun, naturally occurring radionuclides in our bodies, and radiation from the ground we stand on (figure 4). The contribution from plutonium released from the INEEL is tiny, less than 0.002 percent of the 350-millirem exposure.

GLENN SEABORG IN 1997, ON PLUTONIUM, THE ELEMENT HE DISCOVERED

Glenn Seaborg was awarded the 1951 Nobel Prize in chemistry for his work in isolating elements heavier than uranium. He later served as chairman of the Atomic Energy Commission. He was interviewed for "FRONTLINE ONLINE", WGBH Television, on April 22, 1997. The following is an excerpt from this broadcast.

"There are many toxins and viruses that are more toxic than plutonium, that lead to immediate death if taken in amounts equal to what they're talking about as the toxic amounts of plutonium. There have been scientists, as a result of accidents, dating clear back to the war, who have ingested plutonium up to the level of what is considered tolerable amounts. And some of those are still alive, 50 years later. So it's just nonsense to speak of plutonium as the most toxic substance in the world…

"If one holds a piece of plutonium in one's hands, it is not very dangerous. The danger is in the ingestion. These alpha particles then go to various parts of the body: the bones and the organs like the liver and so forth. It's an adverse health effect that takes place over years of time, not like many poisons that act much faster."

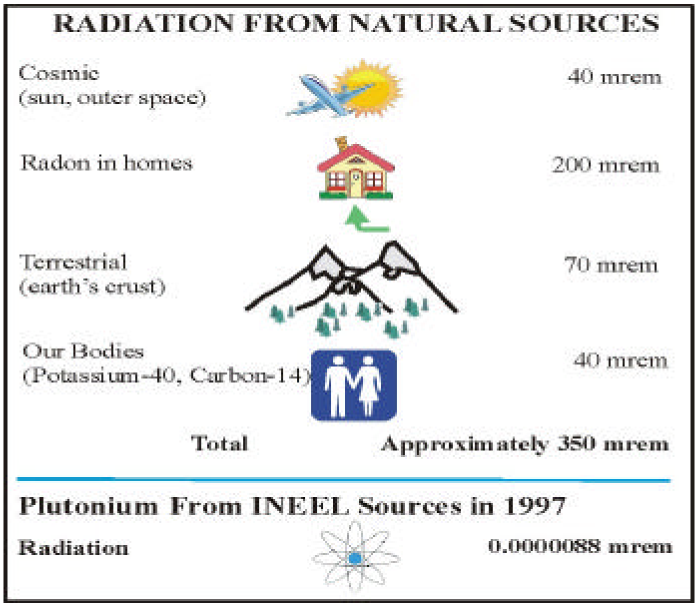

Figure 4. Exposure to natural radiation in Idaho is about 350 millirems per year. Exposure to radiation from plutonium released to the environment by INEEL activities is one ten-millionth of the natural exposure.

How likely is it that you will be exposed to harmful levels of plutonium? The likelihood of you being exposed to harmful levels of plutonium is considered to be extremely remote because plutonium tends to be relatively immobile, and occurs only in isolated, inaccessible, restricted areas at the INEEL. It appears the present risks associated with plutonium are under control and minimal. However, the hazard is recognized and will continue to be monitored, analyzed, and appropriate remedial plans developed via the Comprehensive Environmental Response, Compensation, and Liability Act. You are invited to participate in this process.

YOU CAN BE INVOLVED IN PLUTONIUM SAFETY ISSUES IN IDAHO

Monitoring of plutonium at the INEEL will continue. Furthermore, possible future risk from plutonium migration will continue to be analyzed and appropriate risk reduction actions developed via the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process requiring public participation. We invite *you* to be a part of the public participation.

For additional information about the CERCLA process you may call DOE-Idaho Environmental Restoration Program Manager, Kathleen Hain at (208) 526-4392, or Brad Bugger, Communication Division at (208) 526-0833.

Other forums for public participation are the bi-monthly meetings of the Citizens Advisory Board (CAB) to review INEEL issues and the National Environmental Policy Act (NEPA) which requires public comment on Environmental Impact Statements or Environmental Assessments.

For information about the CAB, contact Woody Russell, DOE-Idaho CAB Coordinator at (208) 526-0561

For information of the NEPA contact Roger Twitchell, NEPA Compliance Officer at (208) 526-0776.

BIBLIOGRAPHY AND SELECTED READING

Plutonium, from the series "Understanding the Atom," United States Atomic Energy Commission, Division of Technical Information, Oak Ridge, Tennessee, March 1966.

Vulnerabilities Associated with the Department's Plutonium Storage, Volume 1: Summary, U.S. Department of Energy, November 1994.

Assessment of Plutonium Storage Safety Issues, at the Department of Energy Facilities, DOE/DP-0123T, January, 1994.

Health Effects of Exposure to Low Levels of Ionizing Radiation, Committee on the Biological Effects of Ionizing Radiation BEIR V (Washington, DC: National Academy Press) 1989.

Final Report to The Secretary of Energy – Implications of the BEIR V Report to the Department of Energy, DOE/EH-0158T August 1990.

Handbook of Health Physics and Radiological Health Handbook, 3rd edition, eds., Shleien, B., Slaback, L.A., and Birky, B.K., Williams and Wilkens, 1998.

Maximum contaminant levels for radium-226, radium-228, and gross alpha particle radioactivity in community water systems, Code of Federal Regulations, Title 40 Part 141.15, July 9, 1976.

Public Health Statement in Toxicological Profile for Plutonium, TP-90-21 by the Agency for Toxic Substances and Disease Registry (ATSDR) of the U.S. Department of Health and Human Services, December 1990.

Fact Sheet, Waste Area Group #1, Test Area North, Idaho National Engineering Laboratory, Nov. 1989, Jan. 1995, Dec. 1995

Fact Sheet, Waste Area Group #2, Test Reactor Area, Idaho National Engineering Laboratory, Feb. 1990, Oct. 1994, March 1997.

Fact Sheet, Waste Area Group #3, Idaho Chemical Processing Plant, Idaho National Engineering Laboratory, Oct. 1994, Nov. 1997.

Fact Sheet, Waste Area Group #4, Central Facilities Area, Idaho National Engineering Laboratory, Aug. 1993, April 1995, June 1997.

Fact Sheet, Waste Area Group #5, Power Burst Facility/Auxiliary Reactor Area, Idaho National Engineering Laboratory, Sept. 1994, April 1995, May 1997.

Fact Sheet, Waste Area Group #7, Radioactive Waste Management Complex, Idaho National Engineering Laboratory, Nov. 1990, March 1994, Feb. 1995, Oct. 1995, Feb. 1996, March 1997.

Idaho National Engineering and Environmental Laboratory Site Environmental Report for Calendar Year 1996, DOE/ID - 12082(96) Environmental Science and Research Foundation, Inc., Idaho Falls, August 1997.

Final Environmental Impact Statement, Waste Management Operations, Idaho National Engineering Laboratory, Idaho, ERDA-1536, Energy Research and Development Administration, September 1977.

The Origin of the Chemical Elements and the Oklo Phenomenon: Kuroda, P.K., Springer-Verlag, New York, 165 p. 1982.

National Emission Standards for Emission of Radionuclides Other Than Radon, From Department of Energy Facilities, Code of Federal Regulations, Title40 Part 61.92, December 15, 1989.

Plutonium Working Group Report on Environmental, Safety and Health Vulnerabilities Associated with the Department's Plutonium Storage, DOE/EH-0415, November 1994

Special Analyses for Plutonium and Americium in Water from the Snake River Plain Aquifer, Idaho National Engineering Laboratory, IDO-12081, November 1976.